NASA Facts

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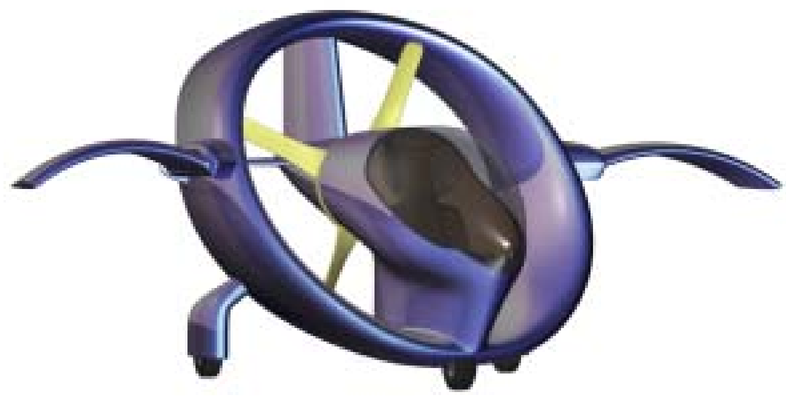
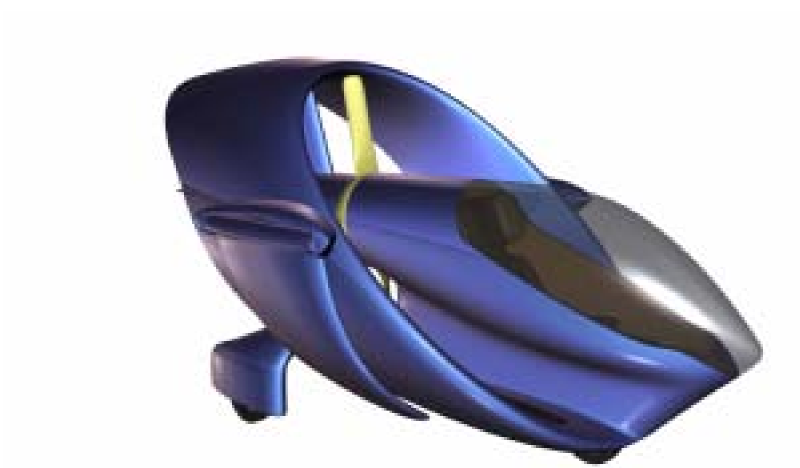
NASA Investigates Future Gridlock Commuter Personal Air Vehicles for Intra-Urban Missions





As highways become more congested, NASA explores an alternative Personal Air Vehicle (PAV) concept that provides fast door-to-door travel options for mid range travel. This advanced PAV concept, the Spiral-Duct, combines highly integrated propulsion and aerodynamic lift in a lifting duct arrangement. The inner duct provides lift and thrust, while the outer panels provide control, even at very low takeoff and landing speeds. This vehicle would be capable of takeoff and landing in less than 250 feet. With folded wings, it could travel on the ground at speeds of 25 mph. Ale to carry 1 to 2 passengers, this very compact and quiet vehicle uses an electric propulsion system that is as efficient as current compact cars. This is just one example of future PAVs that could provide much greater mobility and productivity.

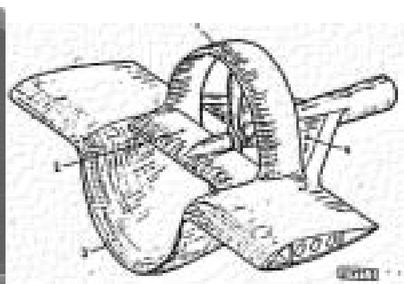
Gridlock Commuter Personal Air Vehicles Could Provide Door to Door Air Travel Solution

Historically, the daily radius of action (or reach) has improved from about 3 miles per day in 1900, to about 25 miles per day (each way) in 2000 for intra-urban travel. Considering the true door-to-door block time, on-demand PAVs have the potential to achieve a daily mobility reach of 125 to 250 miles, providing another five to ten fold increase over the auto. As ground highway and air hub and spoke travel congestion result in increasing delays, the infrastructure investment required to attempt breakeven through these two highly constrained systems will be insufficient and artificially limit economic growth through loss of time and opportunity. While airlines provide a vital mobility service, they don t comprise a significant share of the total market. Approximately 50% of all travel trip-miles involve distances less than 25 miles (accounting for over 90% of all trips), and clearly these short trips will belong to the auto mode of travel for many years to come. Another 40% of the trip-miles are at distances from 25 to 100 miles, and an additional 5% from 100 to 400 miles, with autos currently capturing almost 100% of all these markets. The remaining 5% of trip-miles are at distances greater than 400 miles, with autos still capturing greater than 50% of the long distance travel market as well. Therefore airlines account for only a very small fraction of travel miles, and are currently almost irrelevant for trip distances of 25 to 400 miles, which account for 45% of total trip-miles. PAVS could greatly impact this mid-range travel market.

While roadable aircraft have been attempted for over 50 years, a more practical dual-mode approach might be to require only side-street travel for limited distances in the equivalent of a safe taxi-mode. This capability does not require full compliance with Department of Transportation regulations and safety standards. Instead, these dual-mode vehicles may meet a minimum set of standards that permit the vehicle to achieve a compact taxi-mode with very few air vehicle penalties. By meeting Section 500 vehicle standards, these aircraft could travel at 25 mph on side-streets, as long as they can limit their footprint to a 8.5 ft width and meet some additional relatively simple ground travel requirements. This mode of travel would require the addition of either electric wheel hub motors or a power train from the main engine to the wheel. Though limited roadway use does not overly penalize the air vehicle, it does involve additional weight.

The NASA Langley Spiral-Duct concept was developed as a Gridlock Commuter within the Intra-Urban mission segment of the PAV project. The Gridlock Commuter vehicles achieve the door-to-door service through the section 500 roadworthiness requirement. The Spiral-Duct is based on two prior designs, the Aerodyne, as pioneered by Alexander Lippisch, and the Custer Channel wing. Both of these designs were able to demonstrate ESTOL performance with few or no moving parts in the high-lift system. The Channel Wing achieved a natural thrust vectoring capability that is a function of airspeed. At low speeds the flow is deflected up to 26 degrees while at high speeds the flow is deflected only a small amount. This occurs because the propeller is located in the wing channel , thus increasing the circulation lift on the wing more dramatically at lower freestream velocities due to a higher effective exhaust blowing coefficient. While the Custer implementations of the channel wing were typically dual channels, Hanno-Fischer utilized a single channel to eliminate asymmetric lift vulnerabilities at low speed operations where most of the mishaps of Channel Wing flight tests occurred. A single duct arrangement also provides the maximum ducted propeller area, and minimum disc-loading, within the confines of a span constraint.

Lippisch Aerodyne



Custer Channel Wing

The desired power in an engine size no less than 100 hp, is matched between takeoff requirements and the 125 to 150 mph cruise speed. This results in minimizing the disc-loading of the propulsion system and maximizing the low-speed thrust, leading to ducted propeller concepts for safety of operations. The highly integrated propulsion-aerodynamic coupling enables a 250 ft extreme short takeoff capability with no external high-lift system moving parts, and a Clmax of 6 to 10, depending on the blowing and trim conditions. Low-speed roll control must be sufficient to handle gust control down to the 30 mph approach speed that is required to meet the takeoff and landing field lengths., which would typically lead to either the implementation of active blowing or over-sizing of control surfaces. However, for this concept integration, roll control can be achieved through the use of moving outer wing panels. For a ducted propeller arrangement, yaw and pitch control can be enhanced through embedding the control surfaces into the propeller flow. This causes the yaw and pitch control to be coupled to the propulsion system. For this reason, active controls may be required in order to achieve programmable control surfaces as a function of power and to alleviate the close coupling pitch and yaw trim sensitivity.

Use of a Spiral-Duct arrangement permits approach angles up to 40 degrees angle of attack without tail scrape, which is critical in order to achieve the very high Clmax demonstrated by the Channel Wing.. Due to the propeller flow over the channel, the duct flow has been shown not to stall up to angles of attack of 45 degrees in NACA wind tunnel tests. The SpiralDuct has upper and lower lifting duct surfaces to provide a circular biplane effect, which improves the Oswald efficiency factor by a 1.69 ratio over a monoplane design (though only over the duct span). The outboard panels articulate downward to provide a failsafe folding wing structure with the total span for a 6.5 ft duct being 14 ft, but with an effective span of 16 ft. With this span being essentially the largest simple structure that could practically fit on roadways, it is obviously critical to limit the gross vehicle weight to keep induced drag at reasonable levels. Therefore this type of vehicle has both limited range and payload, offering at most the ability to handle 1 to 2 passengers (though 72% of all auto travel only involves one person) with a gross weight of less than 1000 pounds. For more information, visit http://www.larc.nasa.gov